Defense Technical Information Center Compilation Part Notice

ADP014996

TITLE: Electrical Diagnostics of a Macroscopic rf Plasma Display Panel Cell

DISTRIBUTION: Approved for public release, distribution unlimited

This paper is part of the following report:

TITLE: International Conference on Phenomena in Ionized Gases [26th] Held in Greifswald, Germany on 15-20 July 2003. Proceedings, Volume 4

To order the complete compilation report, use: ADA421147

The component part is provided here to allow users access to individually authored sections of proceedings, annals, symposia, etc. However, the component should be considered within the context of the overall compilation report and not as a stand-alone technical report.

The following component part numbers comprise the compilation report:
ADP014936 thru ADP015049

Electrical diagnostics of a macroscopic rf plasma display panel cell

B. Caillier, Ph. Guillot, J. Galy, L.C. Pitchford, J.P. Boeuf.
Centre de Physique des Plasmas et Applications de Toulouse,
Université Paul Sabatier, 118 route de Narbonne, 31062 Toulouse Cedex, France

1. Introduction

Although Plasma Display Panels (PDPs) are now produced industrially, their luminous efficiency is still low, on the order of 2 lumens per watt (lm/W) or less, and needs to be increased up to 5 lm/W. Research efforts are directed toward the increase of efficiency by optimization of the electrode and cell design or by seeking more efficient discharge regimes. Recently some attempts at operating PDP cells in a RF regime have been made[1]. The RF regime is much more efficient than the usual dielectric barrier discharge ac regime because the better electron confinement allows lower operating voltages. Less energy is therefore dissipated in ion heating in the sheaths, and the lower electric field allows a more efficient energy deposition into xenon excitation (the efficiency of the PDP cell is directly related to the UV emission of the xenon resonant and excimer states[2,3,4]). It was shown experimentally[1] and with numerical simulations[2,3,4] that the efficiency of RF PDP cells can be up to 4 times larger than that of standard ac PDP cells for RF frequencies on the order or larger than 40 MHz. The application of RF power at 40 MHz to a 42 in. Plasma Display Panel is however a big challenge because of the large capacitive currents and because the wavelength of the electric field at this frequency is not large with respect to the panel dimensions (and the electrodes are no longer equipotential). More work is necessary to study the practical feasibility of RF PDPs.

In this paper we present electrical characteristics of the plasma in a "macro-cell" which is related to a real PDP cell by scaling laws (constant pd, pt, and E/p, where p is the gas pressure, d is the gap spacing, t is time or reciprocal of the frequency, and E is the electric field). The macro-cell is 100 times larger than a real PDP cell, but the pressure is 100 times lower. To the extent that gas chemistry does not affect the electrical properties, the scaling laws are valid and can be used apply our measurements to PDP conditions. We present electrical measurements of the power dissipated in the cell and compare them with results from simulations in PDP conditions.

2. Experimental set-up

The macro-cell is represented in Fig. 1. The cell walls are made out of glass (0.5 cm width). The cell is pumped, baked at 300 °C for several hours, filled with a Xe(4%)-Ne gas mixture at 5 torr, and sealed. The electrodes are placed outside the glass vessel (capacitive coupling) on the external faces. The gas gap is 3 cm; the electrode spacing is 4 cm.

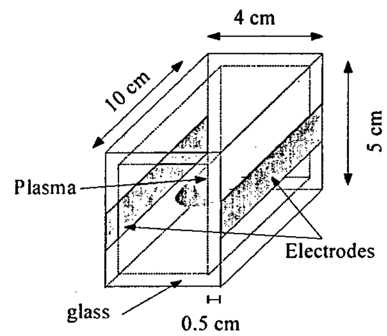


Fig. 1: “Macro-cell” used in the experiments. In the results presented in this paper, each electrode entirely covers one cell face (dimensions 10 cm x 5 cm).

The voltage frequency is varied between 1 MHz and 3 MHz (which would correspond to 100 MHz to 300 MHz for a real PDP cell).

The power dissipated in the cell is measured with two methods. The first one is the Lissajou method which is illustrated in Fig. 2. The voltages across the discharge electrodes from the oscilloscope are plotted as a function of the voltage across a capacitor in series. The power is obtained by measuring the area of the Lissajou curve (Fig. 2):

$$P = \frac{1}{T}\int I_D V_D dt = \frac{C}{T}\int V_D dV_C$$

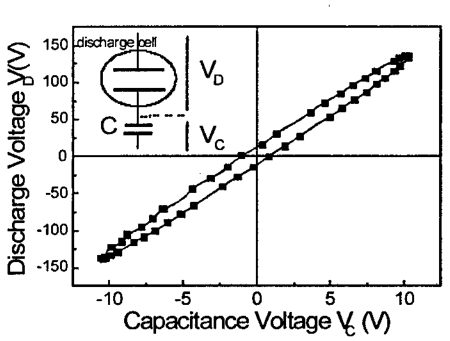


Fig. 2: Example of power measurements with the Lissajou method (conditions: Xe(5%)-Ne, 4 torr, 150 V, 3 MHz)

The second method is a simple bridge method where the capacitor C_V (Fig. 3) is adjusted so that the voltage V_1 and V_2 are equal for given applied voltage when there is no plasma in the cell. When the plasma is ON, the power is deduced from the measurement of (V_2-V_1).

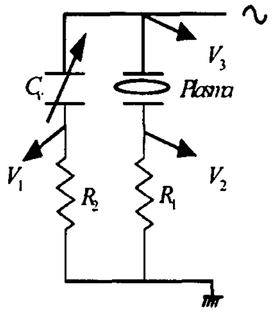


Fig.3: Scheme illustrating the electrical measurement with a bridge method.

3. Results

Figure 4 shows the power measured as a function of applied RF voltage amplitude for different frequencies.

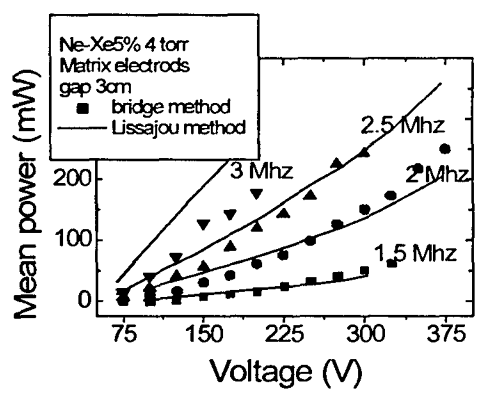
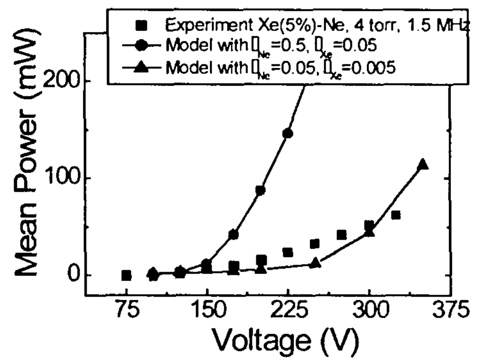


Fig. 4 : Measured mean power versus applied voltage for different frequencies with two different methods (see text)

The two methods gives similar results except for the higher frequency case where the discharge is more capacitive and the accuracy of the measurement needs improvement.

The measured power was compared with results from a 1D fluid simulation of the discharge[4]. As seen in Fig. 5, the simulation results strongly depend on the secondary electron emission coefficients on the dielectric surface. A reasonable fit is obtained when the secondary emission of neon ions is taken to be 0.05 (0.005 for xenon ions). Note that the glass wall is not coated with MgO in these experiments.



FFig.5 : Measured and simulated mean power as a function of RF voltage amplitude for two values of the second Townsend coefficient.

The shape of the power vs voltage curve suggests that the discharge operates in the α regime (i.e. power dissipation due to the sheath oscillation is dominant).

The calculated plasma density is on the order of a few 10^8 cm^{-3} for a frequency of 1.5 MHz at 100 V RF voltage amplitude. This is in rough agreement with the estimation based on the analysis of the current waveform assuming that the discharge can be represented by an equivalent circuit composed of a resistor (bulk plasma) in series with the sheath capacitance (deduced from the optical measurement of the sheath thickness).

Infrared xenon and neon visible emission from the cell have also been measured as a function of applied voltage and frequency. From these results, we infer that the efficiency for power deposition in xenon excitation decreases with increasing voltage for a given frequency. The results, when compared with ac PDP measurements, show that the power is much more efficiently dissipated into xenon excitation in a RF PDP cell. These results will be further described in the poster.

References

[1] J. Kang, J. SID 8, 223 (2000); J. Kang, W. G. Jeon, O. D. Kim, J. W. Song, J. P. Boeuf, and M. H. Park, IDW'99 Proceedings, p. 691 (1999); J. Kang, O. D. Kim, W. G. Jeon, J. W. Song, J. Park, J. R. Lim and J. P. Boeuf, IDW'00 Proceedings, p. 643 (2000).

[2] S. Cany, J. Kang, C. Punset, and J. P. Boeuf, IDW'99 Proceedings, p. 751 (1999).

[3] M. Kurihara and T. Makabe, J. Appl. Phys. 89, 7756 (2001).

[4] L.C. Pitchford, J. Kang, C. Punset, and J.P. Boeuf, J. Appl. Phys. 92, 6990 (2002)

[5] B. Caillier, et al, "Plasma Display Cell Operating in a RF Regime" ,ESCAMPIG 2002, I-355.